West Ward Elementary
Lego Robotic Winch
Final Report

Robotics was the focus for West Ward Elementary students in the reduced gravity experiment. Specifically, how friction, weight, and power affected the strength of a Lego robotic winch on Earth and in microgravity. Students hypothesized that the winch would pull the greatest amount of weight and run more efficiently in microgravity.

A series of experiments were made to determine how the winch performed. We changed the friction level by pulling weight through and over varying surfaces like wood chips, water, smooth table tops, and rolling dowels. We had trouble keeping the Velcro latch from pulling apart and keeping the load balanced as the weight increased. Despite the problems we were able to determine the winch's weight capacity for each friction level. Just as we predicted the less fiction encountered and the greater the power level use the more weight the winch pulled. The weight capacity in the lab setting was 22 pounds through water at high power. In microgravity the power level had no apparent effect on how the winch performed as we were able to pull Mrs. Adams using either power level. The weight capacity in microgravity was not determined, however, we summarized that it would far surpass any tests done in Earth's gravity due to two determining factors. First, there was very little friction that occurred in micro gravity, much less than we encountered in any of our lab scenarios. Secondly, the weight itself was no longer a factor with the reduction of gravity. Data from the flight experiments supports this conclusion. During one of the microgravity runs the weight begin moving down the track as it were being reeled in before the experimenter even turned on the winch. The weight had no resistance from friction or mass to keep it in place. Student hypothesized that this may have far reaching ramifications if this system was operating in Space. On a larger scale disaster could occur if the floating tether were to backlash snapping the Space Station or Shuttle much like a bull whip.

As soon as we began testing the winch we encountered problems. We had trouble with the spool and gears. We learned that in order for the gears to function properly their alignment was crucial and that locking the Lego's together too tightly would cause the gears to bind. We worked these problems out by testing different size, type and gear placements as well as different structural designs. Once we had the binding eliminated we were able to focus on the tether. The tether or pull rope kept getting tangled in the gears and misaligning on the spool. We thought this problem would be worse in microgravity as the weight was free to float about allowing the tether to easily become tangled in the gears. We summarized that in order for the tether to remain tangle free it had to align properly on the spool and be prevented from contacting the gears. Three solutions to this problem were developed and tested.

We built a track that contained the weight and tether so it couldn't move around and get tangled. Velcro was used to attach the weight to a Lego cargo sled that moved on rolling dowels. The cargo sled was then attached to the winch using the tether's Velcro latch. This track system performed perfectly in all testing situations including microgravity. With the tether contained it was unable to contact the gears and remained perfectly aligned on the spool.

Data collection was twofold during flight operations. Video data recorded the behavior of the two winches in microgravity while test conductors took notes, after each parabola, of any interesting dynamics or errors that occurred. Students also compiled notes about the winch's performance in lab setting. Post flight, the students compared the performance of the free floating tether system to the track system by analyzing the number of breakages, tangles, and spool misalignments that occurred, as well as the mass each system was capable of pulling. These results were also compared to the data students had collected.

Overall, the winch performed more efficiently in the micro gravity environment than an environment with gravity as the students had predicted. Friction and power proved to be the determining factor in the amount of weight each winch could manage.

Educationally, this experience has been a success for all those involved. From the start, students were given ownership in the entire process. Student engagement and interest levels remained high throughout the entire process. The challenges we faced acted as catalysts inspiring students to reach for solutions that were once unforeseen. They were able to design, build, test and refine a robotic winch, as well compile and analyze data. Student notes, link ups with NASA, demonstrations, conclusions, and movies documenting the process all show a clear understanding of this entire scientific process. Because the experiment took a year longer than expected to complete, the number of students involved was doubled. As 2005 5th graders graduated, a new group of 5th graders took responsibility for the experiment. During the flight week link up, both groups of student united and took part in the NASA link up with their site teams. All students involved asked questions to their flight crew team members and viewed video recordings of the events during flight. Teachers and students alike were proud to take part in this successful endeavor no matter what role they played. Presently, students have made two movies and are in the process of making a third that documents the entire two-year-long process from the design and building phase to the flight recordings and final conclusions made. Students took pictures and video, helped with script writing and narration and, using Movie software, were able to create an informative visual presentation of the events that occurred. These movies have been used to share the students experience and learning process with parents in the form of take-home DVDs, for teacher-made presentations, during the SEEC conference, as well as student-made presentations for Explorer School activities.

Additional information:

Outreach events performed /planned:

- DVS for distribution to other NASA Explorer Schools interested in the Reduced Gravity Program.
- Articles posted on district and school web site and local TV channel 17.
- Future presentations at NSTA and JSC Conference for Educators in 2007.

Student educational outcomes:

- Increased interest and attendance in the after-school robotics program.
- Students have seen their work in a real-life situation and are motivated to do more because they have had a meaningful real world experience.
- Our school received the second highest district science scores in the district assessment shortly after our flight. There are 29 elementary schools in Killeen ISD.
- Two students and a teacher will represent West Ward at the NASA student symposium in Washington D.C. They will discuss the flight and experiment.

Evidence of impact:

- Increased attendance for all science activities, including after-school activities.
- Weekly reports in student's journals read weekly by Mrs. Adams, flier two, indicate that students were thrilled, amazed and proud of their accomplishments. Students posed many higher level questions to Mrs. Adams…and still do!
- High test scores in science indicate interest, motivation and knowledge transfer of the scientific process employed throughout the project.

Evidence of teacher/community outcomes:

- Five teachers recently completed the Carnegie Mellon Online Robotics Training.
- The Killeen School District has allocated additional funding for a full time science and robotics teacher at West Ward.